# A development strategy for infrastructure asset management information systems in KOREA

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**ABSTRACT**

The maintenance cost for the SOC is increasing as the structures deteriorate in Korea. Many maintenance agencies are trying to find a way to reduce the cost effectively. Several best practices which had applied asset management to infrastructure maintenance successfully were reported in some countries. There is a tendency to introduce asset management in Korea. Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision making. Thus, asset management provides a framework for handling both short and long range planning. It is essential to develop computerized systems in order to do asset management efficiently because the systems require huge amount of data and heavy calculation. There exists some redundancy in data and functions because asset management includes maintenance functions. An effective strategy to develop asset management systems is suggested. Core functions supporting asset management will be developed and legacy systems and data will be shared while redevelopment of existing functions and data will be minimized. This will help soft adoption of new asset management in economic and flexible way.

## 1. INTRODUCTION

Social overhead capital (SOC) such as roads, bridges, water and waste water facilities, parks and social welfare facilities must be serviced with relevant quality above a certain level in order to ensure a smooth economic operation for the communities and the state. As such, they constitute important public assets. With the increasing population concentration in cities and a growing need for convenience, SOC is on the rise. However, since an increase in maintenance budget is smaller than an increase in SOC, the budget does not fully meet the demand, therefore calling for an optimal budget investment to ensure an efficient management of facilities with a minimum cost. A systematic management of public facilities is increasingly important not only for developed nations where SOC facilities are remarkably dilapidating, thus leading to a rapid increase in maintenance cost, but also for Korea where public assets are rapidly multiplying.

Social infrastructure asset management (AM) is a new concept in facility management response to these demands; as such, through AM, the most reliable data concerning facility maintenance are gathered and analyzed, and diverse technologies including data management systems are utilized, thus making a decision on an optimal economic maintenance plan. In recent years, developed nations such as the USA, the UK and Australia revised pertinent laws and regulations, established asset management organizations, and built relevant systems in a bid to activate asset management. There is a strong need to introduce an asset management system for social infrastructure management in order to save management budget and increase asset value in Korea.[1][2]

The social infrastructure asset management system (SIAMS) encompasses a new concept of

public facility, and should support a wide range of work from engineering decision to budget investment decision. Thus, the SIAMS should support complicated decision making, making it essential to utilize information systems, since government agencies, local governments, public corporations should participate in the project, produce and share a variety of information, and analyze a large quantity of information. The SIAMS can provide objective, scientific grounds to help efficiently exchange and share a variety of such maintenance information, and establish maintenance plans, and allocate budgets, as well as enables diverse forecasts and analyses. [2]

However, Korea should consider various aspects in order to develop such a multi-functional asset management information system. Since many agencies use their own systems, it should be considered to reuse legacy systems in developing a new asset management system. Also, social infrastructure management agencies mostly perform similar work, and this may lead to a duplicated system development hence a waste of budget. To plan for across-the-board maintenance budget, and to allocate such budget, the central government will need a new system to comprehensively manage assets.

Australia's IIMM(International Infrastructure Management Manual) defined asset management information system as "a combination of processes, data, software, and hardware applied to provide the essential outputs for effective AM such as reduced risk and optimum infrastructure investment". Key attributes of modern AM systems are that they;

- are modular and have an open architecture that permits the integration of additional modules
- operate across a range of hardware platforms using common industry standard operating systems
- operate across a range of common industry standard databases, e.g. Oracle, SQL-Server
- interface with other corporate systems
- enable flexible report writing
- accept data from external and remote sources.

The asset management information systems can answer the following questions according to IIMM in order to be equipped with necessary functions.[3]

- What property do you have?
- How much is value of property?
- How about present state of property?
- What activity do you need?
- When do you need this activity?
- How much is expense that is cost in this activity?
- How will you finance?

Also, the US FHWA(Federal Highway Administration) defines the asset management information systems as the systems that can answer the following questions.[4]

- How about state of present property?
- How about required level of service?
- What properties are most important?
- What are best preservation supervision and improvement strategy?
- What is best long-term funding strategy?

As such, in building the asset management information systems, in terms of system aspects, open architecture, standard and data linkage are emphasized; in terms of functional aspects, asset condition survey, asset valuation, maintenance activity, and funding strategy are stressed. The asset management information systems should be developed under well defined methodology, as well as be equipped with appropriate technologies and tools, to support these individual components. Such key items should also be closely linked with one another. These are essential considerations in developing the asset management information systems.

## 2. SURVEY OF CASE STUDIES

### 2.1 Australia's Case

Under Australia's IIMM, asset management systems' functions are classified into routine maintenance function and long term planning function according to management criteria, as well as into core asset management function and advanced asset management function according to levels of

importance. This is a good example for Korea to develop its asset management system model.[3]

(1) Functional classification by management criteria

A. General Management Functions

- knowing what and where the assets are that the organization owns or is responsible for
- knowing the condition of assets
- establishing suitable maintenance, operational and renewal regimes to suit the assets and the level of service required of them by present and future customers
- reviewing maintenance practices
- implementing job/resource management
- improving risk management techniques
- identifying the true cost of operations and maintenance
- optimizing operational procedures

B. Long-term Planning Functions

- predicting the future capital investment required to minimize failures by determining replacement costs
- assessing the financial viability of the organisation to meet costs through estimated rates and charges
- predicting the future capital investments required to prevent asset failure
- predicting the decay, mode of failure or the reduction in the level of service of assets (or their components). And the necessary rehabilitation/replacement programs to maintain an acceptable level of service
- assessing the ability of the organization to meet costs(renewal, maintenance, operation, administration and profit) through predicted rates and charges
- modeling 'what if' scenarios such as:
  - ✓ Technology change/obsolescence
  - ✓ Changing failure rates and the risks these pose to the organisation
  - ✓ Alternations to renewal programs and the likely effect on levels of service
  - ✓ Alterations to maintenance programs and the likely effect on renewal costs
  - ✓ Population change

(2) Functional classification by importance

A. Core Asset Management Functionality

- asset register to store primary asset attributes(type, material, dimensions, quantity, construction date)
- condition and performance monitoring
- risk assessment(recording asset criticality)
- maintenance management

B. Advanced Asset Management Functionality

A Core system may evolve in line with business needs to expand this core functionality, introducing advanced tools to assist with decision-making;

- financial management
- risk management
- predictive modeling
- lifecycle costing
- treatment options and costs
- optimised decision-making
- works planning
- interfacing and data import/export

Other non-core functionality that may be provided includes;

- contract management
- job/resource management
- inventory control

## 2.2 Korea's Cases

HMS, BMS, and PMS aimed at managing facilities on the national highways were examined, and data were studied that can be utilized for asset management.

(1) Highway Management Systems (HMS)

HMS, which is a national highway milestone management system, provides relevant information visually, and helps find locations easily, making it easy to identify location information on spaces. HMS has functions to search road inventory, bridge, pavement, traffic volume, cut slope, and other attributes, as well as drawings, digital map and other graphic information. HMS include such management data as road information, region information, road inventory, bridge information, tunnel information, tunnel specifications, tunnel structures, pavement information and cut slope specifications.[5][6]

(2) Pavement Management Systems (PMS)

PMS has functions to search pavement condition, pavement structures, maintenance history, and road condition assessment. The maintenance method and priority decision is based on the net present value (NPV) which considers a difference in total costs (a discount rate: 7%) for five years of analysis using the World Bank-developed HDM-4 program. The management data include pavement information, asphalt pavement structure, concrete pavement structure, maintenance history, maintenance work details, budgeted maintenance history, pavement condition assessment information, pavement condition by year and traffic volume.[7][8]

(3) Bridge Management Systems (BMS)

BMS has functions to search bridge information, bridge structure specifications, bridge condition state, and bridge maintenance history. To prioritize maintenance projects, the C/S program is used to calculate assessment of load carrying capacity, maintenance priority, reconstruction priority and deficiency index, and to input the results onto BMS. BMS manages data such as bridge information, bridge structure specifications, bridge load carrying capacity, bridge condition state, assessment of bridge accurate safety, bridge maintenance history, reconstruction priority, and maintenance priority.[5][6]

# 3. COMPARATIVE ANALYSIS OF FACILITY MANAGEMENT AND ASSET MANAGEMENT

## 3.1 Comparative Analysis of Functions

A comparative analysis of the facility management systems and the asset management systems is shown in Table 1. The asset management systems, which encompass such concepts as asset value, service levels, and financial analysis on top of the facility management systems, is a business strategy to optimize facility management. In the case of Korea, IT infrastructure is well developed, and the importance of information is highly recognized, thus leading each maintenance agency to have pertinent systems; designing of new asset management systems should reflect their relationship with the existing facility management systems.[2][3][5][8]

Table 1. Functional differences between Facility Management Systems and Asset Management Systems

| | Facility Management Systems | Asset Management Systems |
|---|---|---|
| Definition | Information systems for structural status | Strategy for optimized management of SOC |
| Objectives | - Effective facility information management and application<br>- Maintain optimum quality by condition assessment<br>- Effective investment of maintenance budget | - Improvement of asset value by identifying SOC as an asset rather than dealing it as an engineering analysis object<br>- Maximize user satisfaction<br>- Balanced performance management |
| Characteristics | - Fix on failure<br>- No alternative against accident and failure | - Preventive management<br>- Risk management based on asset valuation |

| | | |
|---|---|---|
| Major Functions | - Management of inspection result and maintenance history<br>- Priority decision | - Optimized management process for improvement of asset value<br>- Customer satisfaction by improvement of LOS |
| Considerations | - Lifecycle cost and performance change<br>- Optimized decision making for maintenance alternatives<br>- Budget planning and control | - Asset value<br>- LOS(safety, customer satisfaction, quality and quantity of services, capacity, reliability, reaction, cost, environmental adaptability, availability)<br>- Analysis of failure and risk mode<br>- Optimized decision making(O&M, requirement management, investment & disposal)<br>- Financial analysis(financial plan, business plan)<br>- Asset management plan |

**3.2 Comparative Analysis of Data**

Of data necessary for asset management, general information, condition state, and maintenance history from the existing facility management systems can be used. To that end, the structure and method of accommodating relevant data into the asset management systems should be flexible. AMS(Asset management systems) should be so designed as to link data - that can be reutilized from the existing facility management systems - to the fullest extent possible, and to input only new data onto the system.[3][5][8]

Table 2. Informational differences among each system

| | AMS | HMS | PMS | BMS |
|---|---|---|---|---|
| BASIC ASSET INFORMATION | •General information<br>•Asset specifications | •Road information<br>•General information (bridge, tunnel, pavement)<br>•Traffic volume<br>•Road images<br>•Cut slope | •Pavement information<br>•Pavement structure<br>•Maintenance history<br>•R/R plan | •Bridge information<br>•Structure specifications<br>•Maintenance history<br>•Inspection/Diagnosis history |
| ASSET STATUS | •Current status<br>•Current performance | - | •Pavement status | • Condition state<br>• Load carrying capacity |
| ANALYSIS | •Optimized LCCA<br>•Forecasting<br>•Risk | - | - | |
| MAINTENANCE | •R/R plan<br>•Alternatives/Cost | - | •Maintenance work priority | •Reconstruction priority<br>•Maintenance work priority |

# 4. DEVELOPMENT METHODS FOR ASSET MANAGEMENT INFORMATION SYSTEMS

As discussed in previous section, since asset management information systems are a concept that encompasses facility management systems, the development strategy for asset management information systems should link with data available from the existing facility management systems to the fullest extent possible. Thus, the scheme of developing asset management information systems, with the focus placed on the standard interface design methods to link the two systems, is outlined as follows.

## 4.1 Divided Development of Systems According to Characteristics of Business and Organization

To make it easy to expand, revise and modularize asset management information systems, it is efficient to divide and develop functions of asset management information systems according to characteristics of the pertinent organization and business. To that end, how to divide systems is important; to link the AM systems with the existing FM systems, it is reasonable to divide and develop functions according to organizations and maintenance work.

As with facility management systems, the asset management systems should be developed so as to boost convenience for both agencies with facility management systems and agencies without them. This will help those organizations which produce and manage the basic asset management data such as general information, condition state and maintenance information. Thus, AM system programs should be developed so as to expand and use the existing systems for those agencies equipped with FM systems, and AM system programs should be developed so as to manage assets to the least extent for agencies without facility management systems. A separate system needs to be developed for the maintenance-related policy making division or the budget control division which do not have pertinent systems.

Agencies relating to facility maintenance are examined in connection with road facilities in order to examine how to divide work and sub systems for the AM systems. Four stages, in the case of roads, are defined according to various agencies' role from maintenance to budget control. The first stage is to manage pavement, bridges and other individual facilities. The first stage, the project (PT) level, includes inspection and assessment of individual bridges, pavement and other road facilities, and listing of maintenance items. In the case of national highways, 18 National Highway Management Offices (NHMO) under the control of Ministry of Land, Transport and Maritime affairs (MLTM) are those agencies which undertake PT level work. The second stage is to manage plural bridges, pavements, and other facilities on a certain network. The second stage, network (NT) level, includes prioritizing of maintenance of facilities on a certain network. In the case of national highways, Road Management Division and Road Environment Division of MLTM undertake NT level work. The third stage is to allocate budget to different facilities of the same category such as pavement and bridges or to forecast finances. The third stage is named asset management (AM) level. In the case of national highways, Director General for Road Policy of MLTM undertakes AM level work. The fourth stage, the top level, is to allocate and reconcile maintenance budget to facilities of different categories such as road facilities and water and waste water facilities. The fourth stage is named cross asset management (X-AM) level. In the case of facilities with nationwide networks such as national highways and national express highways, the Ministry of Strategy and Finance (MSF) undertakes the X-AM level work.

As with roads, maintenance agencies for all other facilities cannot be necessarily divided according to these four stages. Such agencies, according to their characteristics or user needs, can be classified into three stages, namely, PT/NT level, AM level, and X-AM level, or the two combined PT/NT level and AM/X-AM level. Since maintenance agencies perform the similar maintenance of social infrastructure, the proposed four stages system can be flexibly used to the characteristics of agencies.

Figure 1 shows a mapping example of agencies for pavement and bridge maintenance on the basis of the proposed four-stage system.

## 4.2 Linking AM data with Facility Management Systems and Other Information Systems

In Figure 1, the systems in AM/X-AM level use data from the PT/NT level and perform financial analysis, asset management planning, and optimal decision making for maintenance budget planning. To do so, the systems in PT/NT level, which performs facility management, should produce and manage data necessary for the AM/X-AM level work. As a result of AM and FM data analysis, since those data, as shown in Table 2, which are managed by Korea's facility management systems,

consist mainly of contents necessary for pertinent agencies or relevant facility work, asset management-related data should be added to them so that the systems in AM/X-AM level can perform diverse functions under the AM system.

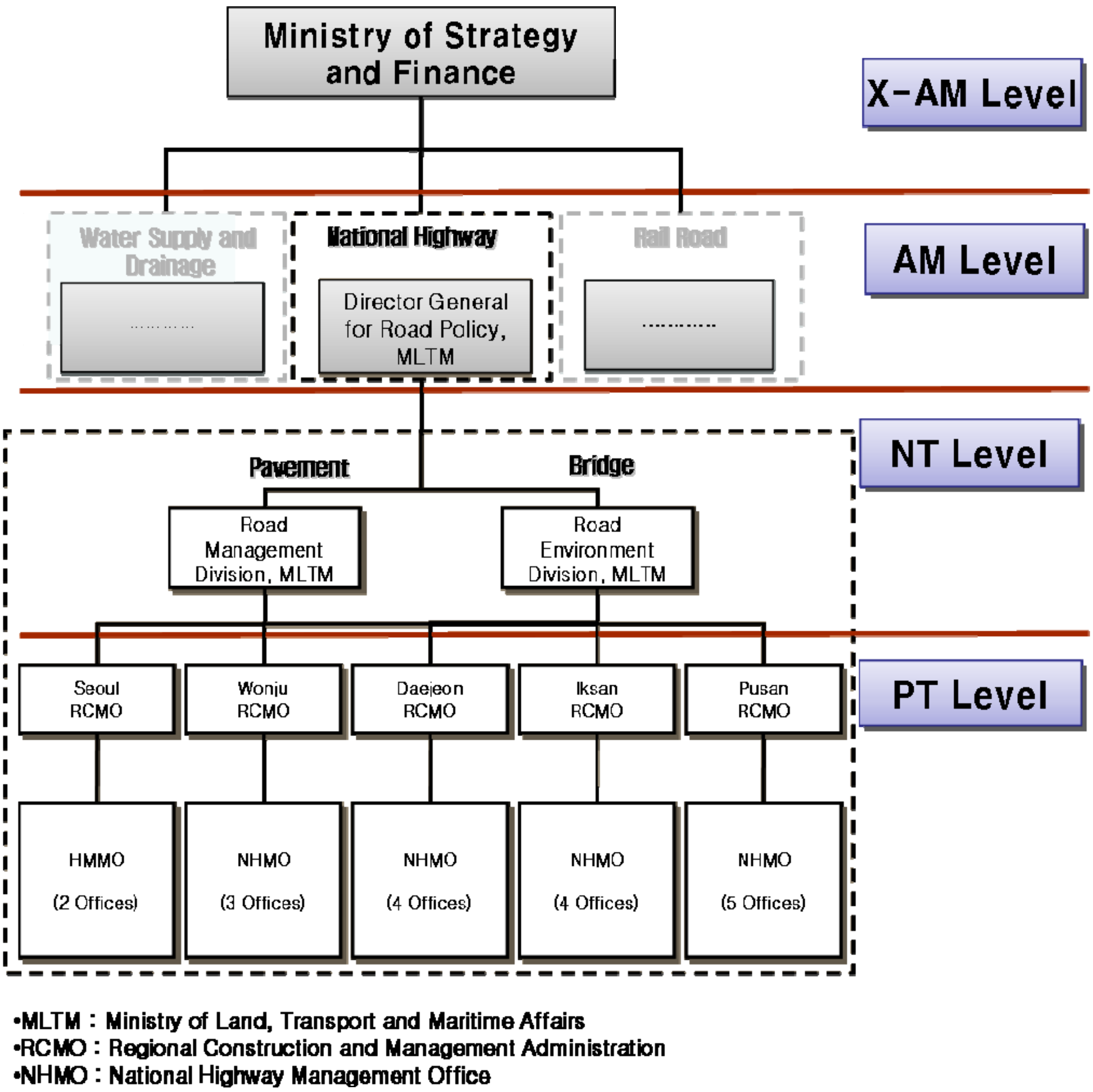


Figure 1. An example of asset management level grouping based on pavements and bridges on the national highway

There are three methods of developing and implementing AM systems while utilizing FM systems. The first method is to add functions so as to input asset management data onto the existing FM systems. This method is simple, but the FM system owner should pay extra costs in order to develop input modules. The second method is to develop a user interface aimed at bringing data from the FM system to the AM system, thus transmitting only relevant data to the upper levels, and to input additional necessary AM data onto the AM system. The method has the advantage of reducing data errors and easily aggregating data, but at the same time requires users to install and learn about relevant programs for using the AM system. The third method is to create data in the form of files suitable for the standard template (Excel or XML) from the FM system, to input additional necessary data onto the templates, and to send the data to the AM system via the standard interface. This method makes it difficult to bring data together, but is the easiest and convenient way for users to use. One of these three methods can be selected according to each agency's characteristics to utilize the FM system.

An agency without the FM system may use the PT/NT level system to manage assets, and may employ the method of transmitting necessary data from the AM/X-AM level via the data interface.

If there is not any computerized program for the processes in PT/NT level, the data can be recorded manually on an input data sheet, and be transmitted via the data interface.

Also, for completeness AM system should be linked with the GIS systems designed to visually access general asset information (location, status, LOS - Level Of Service, maintenance cost, etc.), or with the Supervisory Control And Data Acquisition (SCADA) systems designed to automatically measure the current status of assets then receive the results in real time. And, the AM system should be linked with the budget accounting system so as to enable the AM/X-AM level systems to adjust the maintenance budget, and to transfer the corresponding budget requirements to the budget control division. Figure 2 shows an example of asset management systems' application structure - service architecture - including those features.

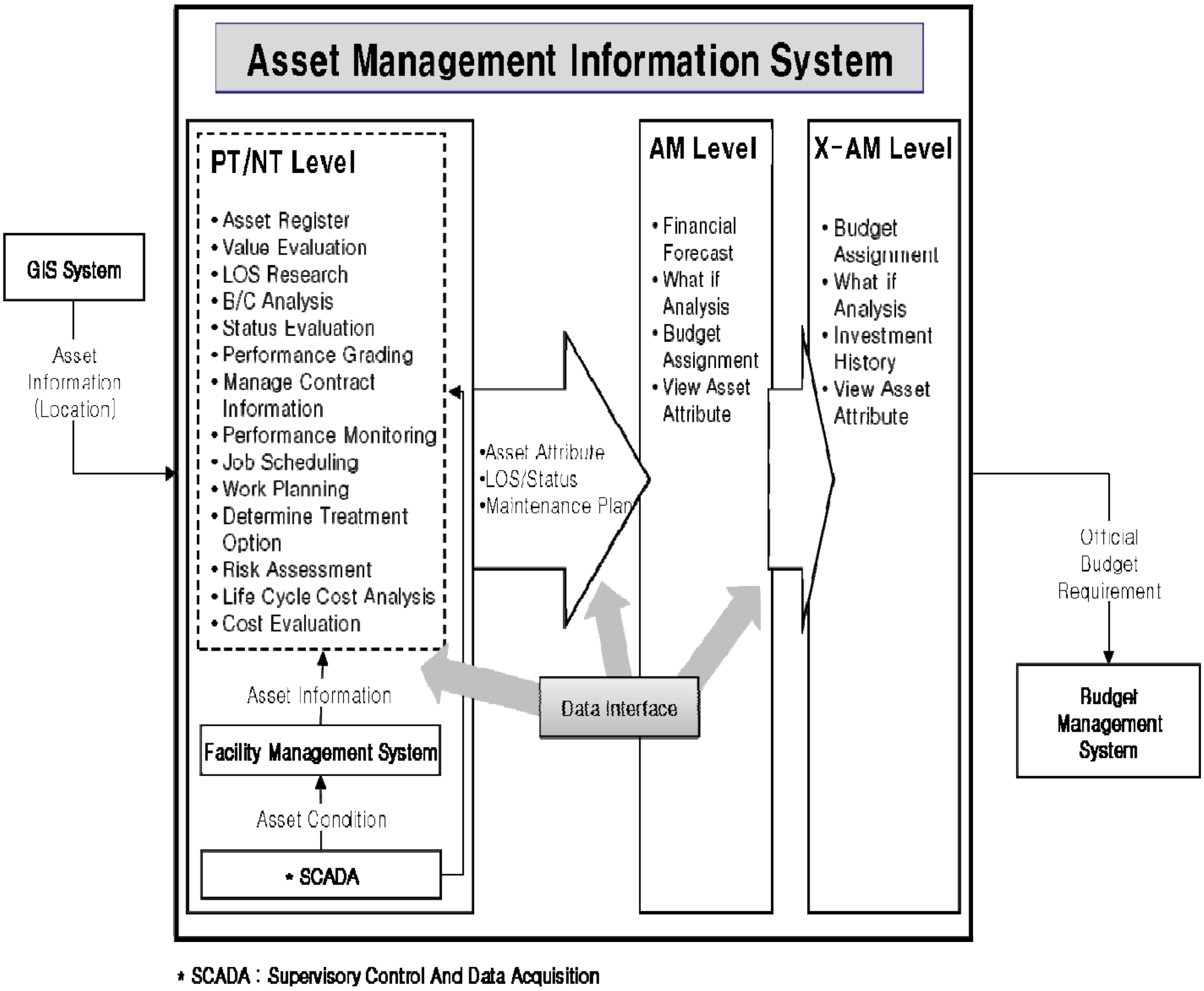


Figure 2. An example of service architecture for asset management systems

As shown in Figure 2, to design data interfaces between each level, standard protocol is essential. In designing standard protocols, input operator, data structure and type, transmission cycle, transmission method, data verification and other diverse factors should be considered. These items have different structures because they should be designed according to characteristics of agencies and work. In this study, of diverse considerations, on the basis of PMS and BMS data analysis, a standard data interface is designed. Figure 3 shows an example of data interface between the PT/NT level and the AM level, on the basis of pavement and bridge data of road facility.

The data interface, in the case of road, consists of three kinds of data. The first one is information about the road itself such as ROAD, ROAD MANAGEMENT AGENCY, PAVED, and LANE. The second one is information describing external data such as STATUS, LOS, TRAFFIC VOLUME, and TRAFFIC ACCIDENT. The last one is information about maintenance work such as PAVEMENT MAINTENANCE and so on. Data interface for bridges are consists of the data same as that of the road. Relevant individual entities include ROAD STATION, STATION AND ROAD, ROAD

MANAGEMENT AGENCY, MINISTRY, PAVEMENT TYPE, ASSET VALUE, RESIDUAL VALUE, LANE, LOS, STATUS, TRAFFIC VOLUME, PAVEMENT MAINTENANCE, PM WORK SITE, TRAFFIC ACCIDENT, BRIDGE, BRIDGE LOCATION, BRIDGE MAINTENANCE, BM WORK DONE, and WORK TYPE.

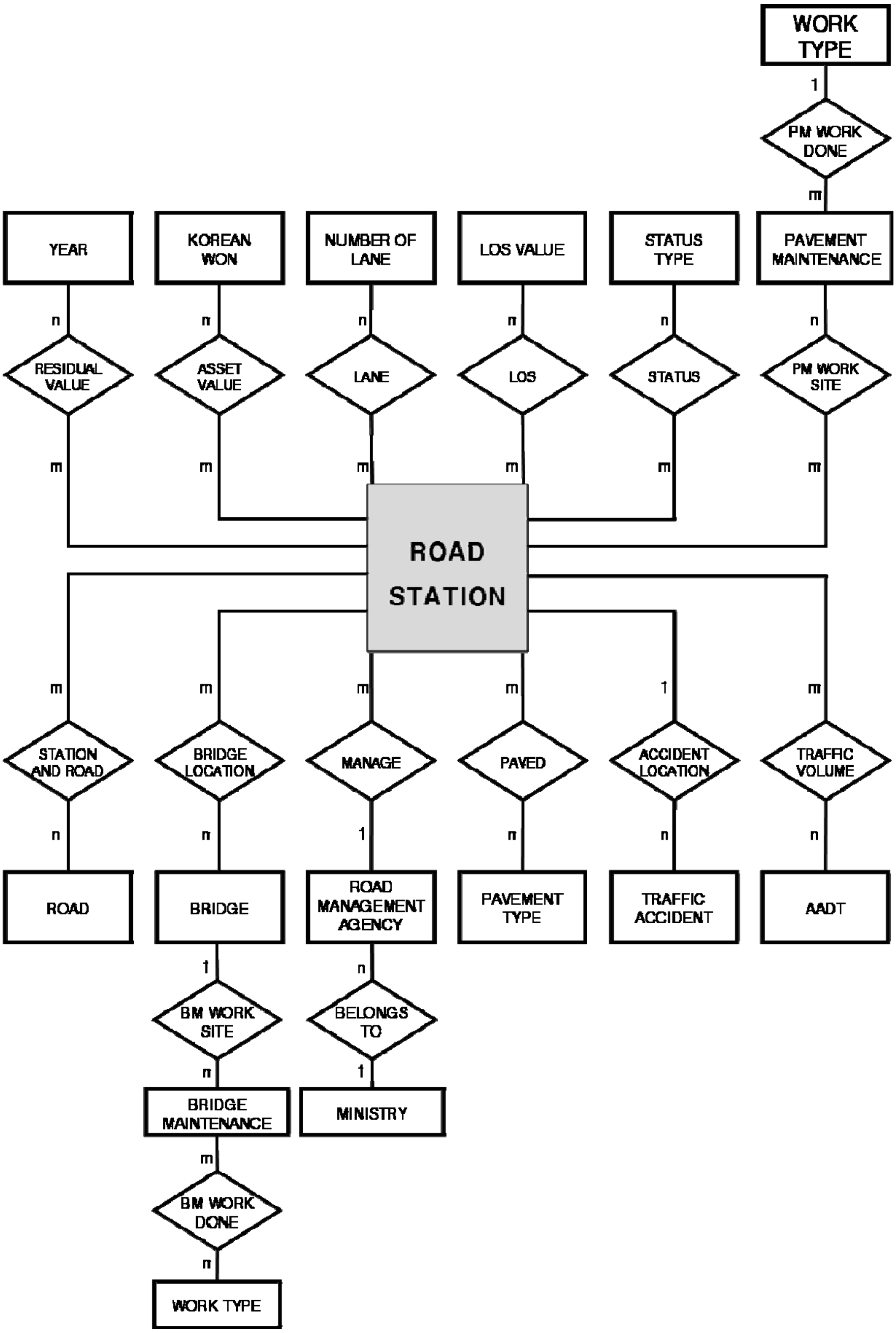


Figure 3. An E-R diagram of data interface for road(pavement, bridge)

The data interface between the PT/NT Level and the AM Level may slightly differ in railroad, airport, road, and water and waste water facilities. However, since the data interface between the AM

Level and the X-AM Level need data to allocate and adjust budget for facilities of different categories such as road facilities and water and waste water facility, it should be designed with data that can compare facilities, such as LOS, maintenance plan, cost, and priority list. Figure 4 shows an example of a hierarchy and the location of data interface for the asset management.

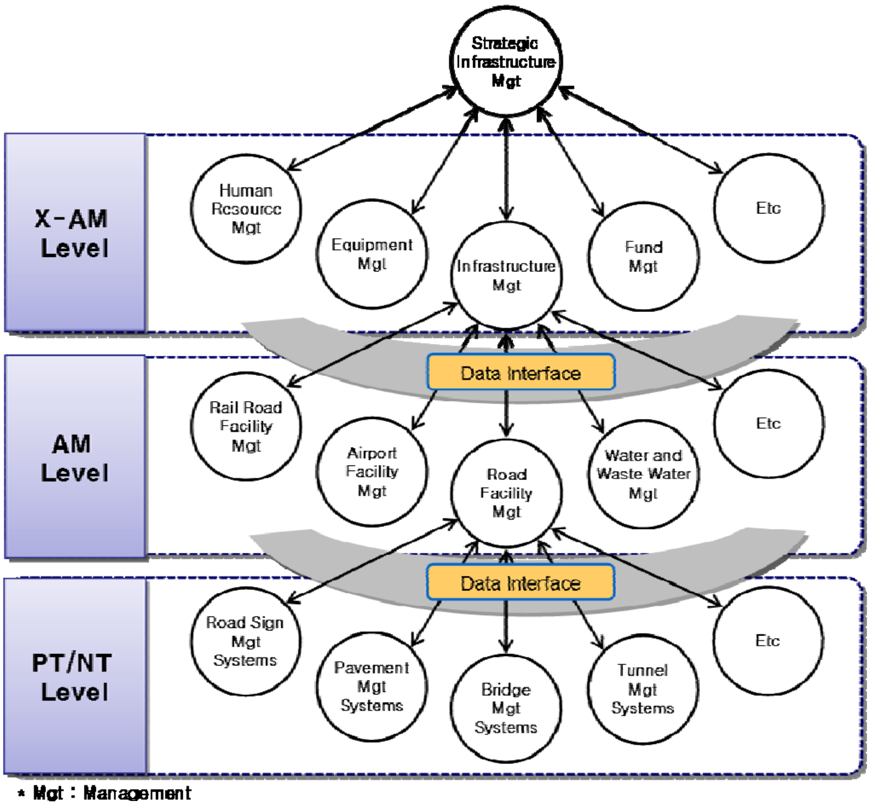


Figure 4. Classified hierarchy and data interface location for the asset management

## 5. CONCLUSION

With SOC increasingly being dilapidated, there is a growing need to introduce the asset management systems to social infrastructures to increase their value and save budgets. Social infrastructure asset management, which is a new concept of facility management in response to these demands, is defined as a procedure by which, after highly reliable data are gathered through facility maintenance activities and are analyzed, diverse technologies such as data management systems are utilized to make a decision on an economically optimized management plan. Various agencies such as central government, local governments, and public agencies, as well as diverse personnel should participate in this work, and support the complicated decision making process whereby a wide range of information is produced and shared, and a large quantity of information is analyzed. Thus, social infrastructure asset management should use information systems.

Good asset management information systems should support open architecture and standards from a system aspect, and require asset condition survey, value evaluation, maintenance activity, and optimized decision making from a functional aspect. Also, to support these components, well-defined methodologies, technologies and tools are needed. The fact that there are many legacy facility management systems is another restraint in developing asset management systems. The new asset management systems should provide easy ways to use the legacy systems in order to introduce them to the user groups of existing systems.

For the overlapping data, the legacy databases should be shared, and new data necessary only for the AM systems should be downloaded from the legacy systems; to that end, a data interface is devised, and proposed as the standard interface between new and old systems. The proposed data interface, in the case of roads, consists of three kinds of data. The first one is information about the road itself, the second one is information describing external data and the last one is information about maintenance work. Relevant individual entities include ROAD STATION, STATION AND ROAD, ROAD MANAGEMENT AGENCY, MINISTRY, PAVEMENT TYPE, ASSET VALUE, RESIDUAL VALUE, LANE, LOS, STATUS, TRAFFIC VOLUME, PAVEMENT MAINTENANCE, PM WORK SITE, TRAFFIC

ACCIDENT, BRIDGE, BRIDGE LOCATION, BRIDGE MAINTENANCE, BM WORK DONE, and WORK TYPE.

To link different systems successfully, it would be ideal to implement tightly coupled systems from a functional viewpoint; however, in consideration of organizations without information systems, a standard data interface is thought to be the best solution. New systems will be designed to have an open architecture by modularizing various functions, and designed to be capable of accepting external data. Also, the government standard EA(Enterprise Architecture) will be introduced to support consistent approaches and industrial standards, thus meeting system requirements. Functionally, with regard to such functions as asset condition survey, asset valuation, maintenance activity, etc., the existing maintenance systems will be utilized, and new asset management functions will be developed, thus meeting the requirements. Agencies equipped with the existing systems can produce data required by the AM systems only through a minimum revision of the systems, and it is important for agencies without the information systems to be able to produce the data conveniently.

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